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SANITATION ON THE ROCKAWAY RIVER WATERSHED¹

BY CHARLES F. BREITZKE

Jersey City is not as fortunate as Newark in having a watershed which it is feasible to own and from which the residents can be removed at will. It can never expect, therefore, to have the ideal catchment area which Newark is gradually evolving, and the problem which Jersey City must solve is to procure a wholesome water supply in a region where conditions are aggravated by the density of a rapidly increasing population. The present supply, taken from the Rockaway River at Boonton, is obtained from a watershed having a population slightly in excess of that on the Croton watershed in a little less than one-third the area. The topography and geology of the Rockaway River watershed bear such an intimate relation to the distribution of the resident population and sanitary problems, that it has seemed best to consider these briefly first.

PHYSICAL CHARACTERISTICS OF ROCKAWAY RIVER WATERSHED

Location of watershed. Jersey City's watershed lies in the Highlands of Northern New Jersey, and with the exception of a small portion in Sussex County, the territory drained by the Rockaway River above the Boonton Dam is located in Morris County. The boundaries of the watershed and of the different tributary streams are shown in the accompanying map (Fig. 1.)

Course of river. The Rockaway River has its source in the Longwood Valley, in which it flows in a southwesterly direction to Wharton, where it takes a tortuous course in an easterly direction guided by steep protruding hills. Winding from side to side in an irregular defile, it flows across three parallel valleys, namely that of Green Pond Brook, that of Mill and Beaver Brooks, and that of Den and Stony Brooks. The main stream flows through each of these valleys in succession until a depression in the ridge enables it to cross to the next valley. On reaching Powerville it takes a southeasterly and southerly course to the reservoir at Boonton.

¹ Read at a meeting of the New York Section, December 20, 1916.

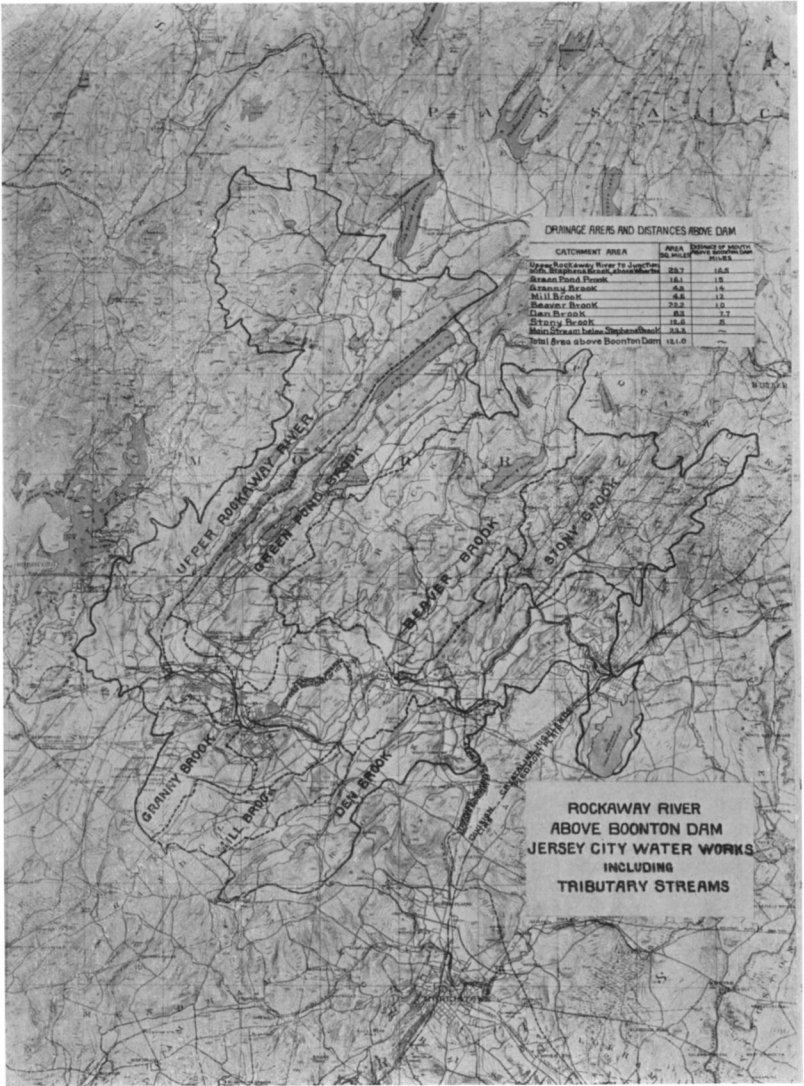


FIG. 1. WATERSHED OF THE JERSEY CITY WATER WORKS

The drainage area to the south extends but a few miles back from the river and the streams draining this section are small. Practically all the important tributaries thus enter from the north in a direction almost opposite to the main stream.

Areas. The area of the entire watershed and its larger subdivisions together with the distances of the mouths of the larger tributaries from the Boonton Dam, are given in the accompanying table.

Drainage areas of Rockaway River catchment basin and distances above Boonton Dam

CATCHMENT AREA	AREA	DISTANCE OF MOUTH ABOVE BOONTON DAM
	<i>square miles</i>	<i>miles</i>
Upper Rockaway River to junction with Stephen's Brook above Wharton.....	29.7	16.5
Green Pond Brook.....	16.1	15.0
Granny Brook.....	4.3	14.0
Mill Brook.....	4.5	12.0
Beaver Brook.....	22.2	10.0
Den Brook.....	8.3	7.7
Stony Brook.....	12.6	5.0
Main stream below Stephen's Brook.....	23.3	
Total area above Boonton Dam.....	121.0	

Underlying rock. Three geological formations occur within the watershed, designated respectively as the Crystalline Highlands, the Green Pond Mountain Belt and the Piedmont Plain.

The first of these forms about 80 per cent of the watershed and consists largely of syenite, granite, gneiss and other crystalline schistose rocks and beds of magnetic iron ore. At Boonton, just above where the river enters the reservoir, this formation is separated from the so-called Piedmont Plain by a fault. All of the watershed west of this fault at Boonton, and east and west of the Green Pond Mountain Belt, as well as a narrow strip between Green Pond Mountain and Copperas Mountains, belongs to this formation.

The Green Pond Mountain Belt is a comparatively narrow zone of conglomerate, sandstone, shale and limestone infolded and down-faulted into the ancient crystalline rocks. This formation is represented on the watershed by Green Pond and Copperas Mountains,

noted for their rugged character and cliffs and peculiar reddish conglomerate studded with white quartz pebbles. There are a very few outcrops of limestone in this belt, for the most part hard magnesium limestone. The effect of these on the hardness of the water is insignificant.

The rocks of the Piedmont Plain belong to the Newark formation. This section of the watershed was once part of the ancient Lake Passaic. The rocks consist of great thicknesses of alternating sandstones and shales. The Boonton Dam and reservoir were built in this formation.

Effects of the ice sheet on topography. Another geological feature having an important bearing on the sanitary problems of the watershed is the change in the topography caused by the great ice sheet which covered Canada and northern United States. There is a marked difference in surface conditions north of the terminal moraine and those south of it.

North of the line the ridges were denuded of all disintegrated rock, transverse depressions were scooped out where the rock was soft, and hard bare summits and irregular jagged ridge lines were left. The slopes were left covered with boulders and in the valleys great masses of gravel and mud were deposited, the thickness of which varies from zero to known depths of more than 250 feet. Much of the soil was rendered unfit for cultivation, by the action of the ice sheet, and a large percentage of the area has been left in forest.

South of where the ice sheet extended, on the other hand, there are but few outcrops of rock, the latter being usually disintegrated and weathered to a considerable depth. The ridges are well covered with soil, the valleys are free from boulders, and consequently the land is more adaptable to tillage than north of the terminal moraine.

Forests. The average forested area for the whole watershed is over 80 per cent. Southwest of Dover and Denville, which are near the terminal moraine about half of the country is in timber. North of the terminal moraine large areas are in forest and the cleared portions are for the most part grass lands. In fact, very few farms are now being worked, the population in the outlying districts is decreasing and in many instances cleared land is lapsing back into forest. It is estimated that nearly 90 per cent of this area is in forest.

Swamps. All valleys contain swampy bottoms, and swamp lands comprising about 3 per cent of the whole drainage area. About half of this is peaty, but its effect on the quality of the water is negligible except in the case of the first run-off following periods of drought, when some color is imparted to the water. While the percentage of swamp lands is very small, they interfere with farming and thus contribute to restrict rural population.

Run-off. Generally speaking, the watershed above the Boonton Dam naturally has a rapid rate of flow. The valleys which the main stream crosses are short, narrow, rocky and bounded by steep slopes, and this formation brings most of the head-waters close to the main stream and causes a rapid run-off.

There is a great variation in rain-fall and stream flow, and periods of drought followed by heavy run-off occur quite frequently. On the other hand underground storage in the drift of the valleys, assisted by the extensive forested areas, combined with leakage from a large number of former forge ponds, produces a fairly well sustained dry-season flow.

Summary. Physically the watershed of the Rockaway River is a desirable gathering ground for a public water supply and yields a soft clear water, usually low in color. The surface conditions are for the most part unfavorable to farming, and outside of the district bordering the main stream, comprising less than one-fifth of the drainage area, the population is either at a standstill or decreasing. On the other hand the rapid run-off after periods of drought followed by heavy rainfall, the coarse glacial drift underlying the most thickly settled district, and the nearness of most points on the watershed to the gate-house at Boonton, offer sanitary problems of considerable magnitude.

SANITARY CONDITION OF WATERSHED

Distribution of population. The depression by which the Rockaway River crosses the highland region is the route of one of the main highways throughout northern New Jersey and all the incorporated towns and boroughs in the watershed are located near the main stream.

The accompanying table gives the estimated present population on the watershed by civil divisions. Where these extend beyond the limits of the catchment area, only populations actually within the watersheds limits are given.

Population on Rockaway River watershed

CIVIL DIVISION	POPULATION OF PORTION IN WATERSHED	
	Permanent	Summer
Boonton Town.....	3,400	3,600
Boonton Township.....	550	650
Denville Township.....	1,000	1,500
Dover Town.....	11,000	11,000
Hanover Township.....	800	1,700
Jefferson Township.....	500	550
Montville Township.....	50	100
Pequannoc Township.....	50	100
Randolph Township.....	1,700	1,700
Rockaway Borough.....	2,300	2,300
Rockaway Township.....	3,000	3,600
Roxbury Township.....	100	150
Wharton Borough.....	3,000	3,000
Sparta Township.....	50	50
Total on watershed.....	27,500	30,000

The distribution of the population among the catchment areas of the principal tributary streams is given in another table. In this table the term "urban" refers to the residents of the towns, boroughs, thickly settled unincorporated communities, mining camps and such summer resorts as have permanent buildings.

Distribution of population on catchment areas of tributary streams

STREAM	AREA	POPULATION 1916			POPULATION PER SQUARE MILE		
		Total	Urban	Rural	Total	Urban	Rural
	<i>square miles</i>						
Upper Rockaway River above Wharton.....	29.7	750		750	25		25
Green Pond Brook.....	16.1	1,300	1,050	250	81	65	16
Granny Brook.....	4.3	700	200	500	163	47	116
Mill Brook.....	4.5	400		400	89		89
Beaver Brook.....	22.2	2,000	1,350	650	90	61	29
Den Brook.....	8.3	1,750	1,300	450	211	157	54
Stony Brook.....	12.6	700		700	56		56
Main Stream.....	23.3	22,400	20,100	2,300	962	863	99
Total Watershed.....	121.0	30,000	24,000	6,000	248	198	50

Details of the distribution of the "urban" population are given in a third table. From this it can be seen that 80 per cent of the

Distribution of urban population

NAME OF SETTLEMENT	GREEN POND BROOK	GRANNY BROOK	BEAVER BROOK	DEN BROOK	MAIN STREAM	TOTAL
Boonton.....					3,600	3,600
Cedar Lake.....					300*	300*
Denville.....				150	200	350
Mt. Tabor.....				1,150*		1,150*
Rockaway.....					2,300	2,300
Upper Hibernia.....			200			200
Lower Hibernia.....			250			250
Mt. Hope.....			900			900
Green Pond.....	600*					600*
Richard Mine.....	350					350
Dover.....		150			10,850	11,000
Wharton.....	100	50			2,850	3,000
Total.....	1,050	200	1,350	1,300	20,100	24,000

* Chiefly summer residents.

entire population on the watershed is concentrated in small areas along or near the main stream. With the exception of Green Pond, where there is only a summer population which is being properly served by privies and cesspools and no sewer system is needed, all these places are within easy reach of a trunk sewer, and if at any time the usual methods of sanitary patrol should be no longer effective in preventing pollution in any or all of these places, arrangements can readily be made to install lateral and connecting sewers.

Comparative data of population on other watersheds

WATER SUPPLY	POPULATION PER SQUARE MILE		
	Total	Sewage diverted	Sewage not diverted
Newark, N. J., Pequannock Watershed.....	14		
New York City, Croton Watershed.....	67		
Boston Metropolitan Water Supply			
Wachusett Watershed.....	53		
Sudbury.....	305	181	124
Cochituate Watershed.....	914	696	218

Comparative data of population on other watersheds the supplies from which are of good quality are given in an accompanying table. Comparing its figures with those in the table of the distribution of population on the Rockaway watershed, we find that, while the ideal conditions existing on Newark's watershed can never be realized in the case of Jersey City's supply, and while the population per square mile of the Rockaway watershed is high when compared to the population on the watersheds of Newark and New York, the experience in the case of the Boston Metropolitan supply shows that it need not cause alarm if proper sanitary protective measures are taken, and that water supplies from such sources are not necessarily seriously impaired by such populations if the sewage is diverted out of the drainage area.

Diversion of sewage out of watershed. In fact Jersey City has been considering such a step for some time and a movement is under way looking to the construction of a trunk sewer. Half of the population on the watershed would be immediately served by such a sewer, and shortly following its installation, it is estimated that the sewage from 22,000 or 73 per cent of the people will be diverted to some point below the Boonton Dam. This would leave on the watershed a balance of 66 people per square mile not served by sewers, of which 16 would represent small communities not having any water supply and 50 a scattered population not presenting any difficult sanitary problem.

SANITATION METHODS ON WATERSHED

Removal of sources of pollution. The laws of New Jersey are very strict with reference to the protection of public water supplies from pollution. Thus Section 1 of "An Act to secure the purity of the public supplies of potable waters in the State," approved March 17, 1899, provides:

1. No excremental matter, domestic, factory, workshop, mill or slaughter house refuse, creamery or cheese factory waste, garbage, dye stuff, coal tar, sawdust, tan bark or refuse from gas houses or other polluting matter shall be placed in, or discharged into, the waters, or placed or deposited upon the ice of any river, brook, stream, or any tributary or branch thereof, or of any lake, pond, well, spring or other reservoir above the point from which any city, town, borough, township, or other municipality, shall, or may obtain its supply of water for domestic use; nor shall any such excremental matter, domestic, factory, workshop, mill or slaughter house refuse, creamery or

cheese factory waste, garbage, dye stuff, coal tar, sawdust, tan bark or refuse from gas houses, or other polluting matter, be placed or suffered to remain upon the banks of any such river, brook, stream, or of any tributary or branch thereof, or of any lake, pond, well, spring, or other reservoir, above the point from which any city, town, borough, township or other municipality shall or may obtain its supply of water for domestic use as aforesaid; and any person or persons, or private or public corporation, which shall offend against any of the provisions of this section, shall be liable to a penalty of one hundred dollars for each offense; and each week's continuance, after notice by the State or local board of health to abate or remove the same, shall constitute a separate offense; provided, however, that nothing in this section contained shall be construed to repeal, modify or otherwise affect any law or statute now conferring upon any local board of health the power of authority to institute any proceedings in any court of this State for the recovery of any penalty for, or obtaining any injunction against, the pollution of any of the waters of this State.

Regulations 3 and 4 of the new State Sanitary Code, which have all the force of law, go still further and prescribe:

Regulation 3. No person or private or municipal corporation shall maintain, use or permit to be used, any privy, or other receptacle for human excrement, . . . unless such excremental matter shall at all times be prevented from flowing over or upon the surface of the ground. Every privy or other receptacle for human excrement located within 100 feet of any stream, the waters of which are used for drinking or domestic purposes, shall be provided with a water-tight vault.

Regulation 4. No person or private or municipal corporation shall permit any human excrement, or material containing human excrement, to remain on the surface of the ground; nor shall such excremental matter or material containing such excremental matter be buried or otherwise disposed of within 100 feet of any stream, well, lake, spring or other source of water used for drinking or domestic purposes; nor shall any such material be deposited in any place where it is likely to gain access to such waters. Provided, however, that this regulation shall not apply to effluents from sewage disposal plants which have been, or hereafter may be, approved by the State Department of Health.

These laws and regulations are very explicit and place the burden of removing sources of pollution on the offenders. On the surface, therefore, it would appear easy to enforce them. In fact, good results have been obtained in this manner in the outlying districts where existing violations are usually open, isolated, and readily detected.

When it comes to enforcing these laws under difficult conditions, such as are frequently found in thickly settled communities, the re-

moval of pollution in this manner is not an easy matter. In this country we cannot enforce sanitary laws as is done in Germany. In order to successfully prosecute offenders, it is necessary that the delinquent be identified, and the offense traced directly and surely to him, with specific proof as to the time and place, and the isolation of his particular offense from the offenses of others unknown.

The proof of pollution depends on circumstances. Often this is a simple matter. Thus, if polluting matter is found coming through a drain, and uranine dye is put into a toilet or sink on the premises under suspicion, and the color passes through, the evidence is sufficient. In many cases, however, pollution, even when clearly apparent, is a difficult matter to prove, as when you fail to get the dye through. Situations like this will occur when a cesspool is large and the amount of overflow small; also in those cases where cesspools have secret overflows which can be opened or stopped at will, or are located in cellars, as in the business section of Dover where, owing to ground-water difficulties, the temptation is great to get rid of cesspool matter surreptitiously. In a congested district where many properties adjoin and cesspools are close together, the question of fixing the responsibility for cesspool overflow is not an easy matter. Similar problems arise when cellar drains are connected to covered drains, and these are secretly used to carry away sewage. Often the points at which pollution enters and where evidence can be obtained are several blocks apart, and the matter of tracing and proving pollution is one which requires considerable patience and skill.

Moreover, it is frequently necessary to prove ownership of property as well as pollution, for at times tenants' testimony as to ownership may be wholly or partly in error, especially in the case of estates, or in sections occupied by a foreign population where agents are often taken for the landlords. In order to prosecute a case successfully, it is essential that the full correct name of the owner be obtained. Often this can be accomplished by obtaining an admission from the owner, making note of the time and date. In other cases the tenant's testimony is verified at the tax office or by talking with the assessor. Sometimes a trip to the county clerk's office is necessary.

Another important factor to bear in mind in enforcing the law, is the good will of the residents of the drainage area. The removal of pollution means expense to the property owner, and when you

touch a man's pocketbook you have a delicate situation to handle. It is essential, therefore, to avoid producing among the population of a watershed a feeling of bitterness and hostility, which would not only be certain to make the control of pollution difficult, but which may lead ignorant and malicious persons to secret acts of reprisal.

The policy which we have been pursuing with considerable success is based on the old proverb about catching more flies with a drop of molasses than with a barrel of vinegar. Most of the pollution has been removed through persuasion, and only in the obstinate cases has it been necessary to call upon the state department of health and the attorney general for assistance.

The procedure followed is, briefly, as follows: The speaker, in addition to his position as sanitary engineer representing Jersey City, was appointed an inspector of the state department of health. This gives him the right to enter private property in the performance of his duties. There are also Jersey City inspectors stationed at Wharton, Dover, Rockaway and Boonton. When cases of pollution are found, they are carefully examined, and an interview is had with the owner of the property where possible, during which the significance of the pollution is pointed out to him. Where personal interviews are out of the question, a letter is sent to the owner calling his attention to the pollution and the law violated, and asking him to abate the pollution. This letter also states that a reinspection will be made at a given date, and expresses the hope that further action to remove the pollution will not be necessary. As far as possible the cooperation of the local boards of health is obtained. In cases where the owner of the property can ill afford to stand the burden, assistance is given. This is usually in the form of labor and in making the improvement either in whole or in part.

All original inspections and reinspections are reported on special blanks provided by the state department of health, and from time to time are sent to Trenton, sorted in accordance with the status of the case as:

1. Reinspection of cases referred to the attorney general.
2. Cases of pollution found abated on reinspection.
3. Cases being taken up directly with the property owners.
4. Cases referred to local boards of health.
5. Cases requiring attention of the state department of health.

The obstinate cases comprising this last group, are as a rule, referred by the state department of health to the attorney general, who has notices to abate the pollution served upon the property owners. In many cases such a notice is sufficient, and usually with the others found still existing on reinspection, a little more persuasion secures the abatement. Thus far it has been necessary to carry only one of these cases into court.

Water-borne diseases. A careful watch is kept for cases of typhoid fever and other water-borne diseases. Through arrangements with the state department of health, there is received a copy of the record of cases as soon as they are reported. The speaker also keeps in touch with the recorders of vital statistics in the various civil divisions of the watershed, to whom, in accordance with Chapter 381 of the Laws of 1911, every physician must report within twelve hours after his first professional attendance upon any person suffering from a communicable disease. These gentlemen have been furnished with addressed stamped envelopes to use for notification of any cases or deaths from typhoid fever, grippe (an indefinite term which sometimes is used to report sickness perhaps of typhoid fever and especially in reporting deaths among the foreign population, where the physician has not been called until too late to properly diagnose the case), typho-malaria, typho-pneumonia, dysentery or other intestinal or diarrheal diseases occurring on the Rockaway River drainage area. Each case, as soon as reported, is carefully investigated and steps taken to disinfect the premises. A supply of hypochlorite of lime is also left on hand, and the place is kept under surveillance until danger is considered past. We are fortunate in having but little sickness of this character upon the watershed, and we do all we can to prevent typhoid fever from getting a foothold.

Toilets on railroad trains. The two principal railroads crossing the watershed are the Delaware, Lackawanna & Western, and the Central Railroad of New Jersey. To avoid danger of the infection of the water supply, arrangements were made through the state department of health on January 15, 1914, in accordance with "An Act to regulate the use of water closets and urinals on railroad trains and other public conveyances," approved April 17, 1909, whereby all toilets are to be closed while trains are crossing over the watershed. An inspection is made from time to time at different points to see that this order is being complied with.

Scavengers. Watch is also kept of the movements and dumping grounds of scavengers. There are three of these doing a big business at Dover, Wharton and Rockaway. The sites on which the refuse is dumped are on the outskirts of these towns at points removed from streams. The town of Boonton does its own scavenger work, the dumping being done outside of the watershed.

Supervision of industrial plants. The operations of industrial plants are also kept under surveillance. The largest of these are a paper mill at Powerville and the Liondale Bleach, Dye & Print Works at Rockaway. At the former, disposal beds have been built through which the liquid wastes soak away into the ground. At the latter, the sewage from some 300 employees is disinfected, and plans are under way to care properly for all the wastes. Inspections of these mills are made from time to time and samples of the effluents and of the river above and below the mill are taken. Samples are also taken periodically at different points on the watershed.

Patrol of river at Dover. The river at Dover is patrolled daily and all papers and other rubbish are removed. This work is also of value in discovering secret drains. The patrolman also attends to the operation of two chlorine treatment plants disinfecting the water from two polluted feeders at Ford Pond and Mercer Street.

Chlorine treatment plants at Dover. These plants were placed over the outlets of two small streams draining two large sections of Dover situated in low ground having numerous blind drains receiving sewage pollution difficult, if not impossible, to trace to its sources. They were intended as temporary make-shifts to reduce the danger from possible pathogenic bacteria until such time as sewers will be built.

The outlets of these streams were formerly crooked, unsightly ditches, choked with weeds, brush and refuse covered with slime and decaying organic matter. The channels were redug, the sides walled up and the bottom paved. An inexpensive building housing chlorine apparatus was in each case placed on a platform over the stream as shown in the accompanying cut (Fig. No. 2). A weir beneath the platform serves the double purpose of making possible the introduction and absorption of the chlorine gas by increasing the depth of the water, and of measuring the flow of the water, so that the amount of chlorine applied may be regulated accordingly. A series of baffles on the down-stream side of the weir effects a thorough mixing of the chlorine with all of the pol-

luted water before it reaches the river. The application of the chlorine is made in accordance with a special chart giving the amount in terms of the depth of water over the weir.

The above chlorine machines were installed in February, 1913, and were, it is believed, the first two put out by Wallace & Tiernan. They were crude in comparison with present models, but for nearly three years gave very satisfactory service. Recently, in changing over from a troublesome hard rubber pipe distributing system to

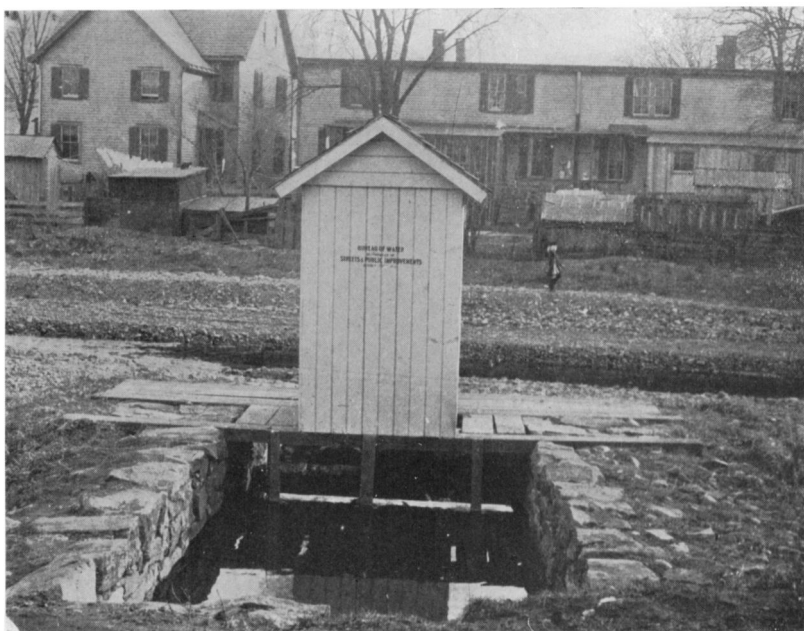


FIG. 2. CHLORINATION STATION AT MERCER STREET

one of silver tubing, the old apparatus was replaced with up-to-date models. Our experience with the use of hard rubber in chlorine work has not been satisfactory. For some reason, whether through deterioration from natural causes, or the action of chlorine in the presence of moisture, or for both reasons, small hard rubber piping becomes brittle and easily broken and cannot be depended upon in chlorine work.

The experience with these plants is also interesting from the standpoint of applying chlorine as a gas directly to waters in shallow

streams. The small weir dams helped, but owing to their location, could not be built high enough to provide sufficient depth of water to completely absorb the chlorine. On the other hand, owing to the exposed location of the plants, the solution or wet method of applying the chlorine was out of question on account of freezing in cold weather. This difficulty was finally overcome by placing a stationary floating board over the diffusers. This intercepts escaping bubbles of unutilized gas and affords opportunity for all the chlorine to be dissolved by the flowing water.



FIG. 3. IMPROVED AND CLEANED RIVERBED

River cleaning. To persons familiar with former conditions, the most conspicuous of all watershed work is the cleaning and improvement of the river bed. Up to the time this was undertaken, the river, especially at Dover, was nothing more than a common dump, and the rubbish which had accumulated there was almost indescribable, ranging from discarded mattresses, cast-off clothing, garbage, tin cans and bottles to defunct cats and fowls. The stream spread out over its entire bed and contained many pools of stagnant

or sluggish water, having bottoms covered with green slimy algae. Weeds and underbrush which grew not only along the banks but in the bed of the stream as well, impeded the flow and enmeshed floating filth of all kinds. In a few words, the appearance of the river was disgusting.

In this work many tons of rubbish and muck were removed. The brush was cut down and burned. Following this preliminary work, the bed of the river was improved by providing a center channel to confine the low flow in a neat and attractive stream. The entire bed of the river was turned over with rakes. Large stones were used to fill in the holes and the remainder piled up neatly along the sides.

This improvement of the river bed had a very noticeable beneficial influence. The general tenor of local opinion was one of praise and commendation. In many instances adjoining property owners became interested in cleaning up their grounds. The benefits derived were twofold, namely, the elimination of the addition to the water of such objectionable bacterial life as refuse matter deposited in the stream may contain, and the moral effect which such action will have on people residing on or near the banks of the stream. When rubbish is kept out of a river and the stream is made attractive to the eye, there is less temptation to use it as a dumping ground.

While up to the present these improvements have been confined to the larger communities, it is the intention of Commissioner Henry Byrne to continue this good work and to extend it to such portions of the watershed as may be necessary.